Virgin Islands National Park

Water Quality Monitoring Protocols

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Rationale for Monitoring Water Quality

The characteristically low nutrient waters that surround St. John provide ideal conditions for the growth of corals, seagrasses, and many other marine organisms. However, while over half of the island of St. John and 2,287 hectares of the surrounding water are protected within Virgin Islands National Park (VINP) boundaries, St. John is subject to the same development pressures that are affecting many other Caribbean islands.

Sparked by tourism-based economies, development in the Caribbean is occurring at an alarming rate. Increased development on land inevitably results in increased erosion and the delivery of sediment from runoff to the nearshore waters and coral reefs. Over the past 25 years, visitation to VINP has increased dramatically, with many people arriving on cruise ships and small boats. In 1966, the average number of boats in park waters was less than 10 a day; by 1994, the number had jumped to 50 a day.

Like other islands, St. John needs baseline data on water quality for researchers and park managers to use in understanding and identifying the changes affecting marine ecosystems.

Historical Data

St. John

- Monthly sampling from 1988 through 1996: temperature, salinity, dissolved oxygen, conductivity, pH, transmittance, turbidity (NTUs), cloud cover, wind speed, and sea state at 29 sites — 16 within and 13 outside the park. A 30th site was added at Newfound Bay 1990. Some data are missing as a result of boat or equipment problems.

- Since August, 1993: monthly analysis of dissolved inorganic and organic nutrients attempted for each site (nitrates, phosphates, silicates and ammonia). Reliable nutrient data since 1994.

- In August, 1994 an additional site was added, on the east side of Haulover Bay, below a proposed development. Total suspended solids were measured weekly for one year.

- After review of the sampling design, the number of sampling sites was reduced to 15 of the original 31, with three replicate samples taken at each site. Extinction coefficients and total suspended solids have been determined at each site, since mid 1997. Sampling is now quarterly (March, June, September and December).

For a complete list of sampling sites, see Appendix B.

Additional water temperature data are collected at four coral reef sites: thermistors register water temperature every 2 hours at Yawzi Point (since May 1989), the Windspirit scar (since October 1990), Newfound Bay (since January 1991) and Haulover Bay West (since January 1998). (See Coral Monitoring Protocols.)

Buck Island: The territorial government (Department of Planning and Natural Resources) has been monitoring water quality at two sites off Buck Island, St. Croix since 1970. Data are available on temperature, turbidity (NTUs), salinity, nutrients, pH, conductivity, transmittance, Secchi depth, dissolved oxygen, and fecal coliform. Water temperature has been recorded every two hours at the forereef on the eastern shore since 1989.

Dry Tortugas A C-MAN buoy maintained by Florida Institute of Oceanography (FIO) records temperature, salinity, dissolved oxygen, conductivity, sea level and PAR (since 1992). Instruments to detect chlorophyll a and turbidity were added in Spring 1998. Dr. Ron Jones of FIU has monitored water quality at stations throughout the Florida Keys and Florida Bay on a quarterly sampling schedule: temperature, salinity, and nutrients.

Monitoring Design Considerations

Certain physical and chemical properties of water are measured quarterly for possible correlation with changes observed on the reefs. Most coral species can survive only within narrow salinity and temperature ranges, and any marked changes in parameters such as light transmission, sedimentation, and dissolved oxygen may affect the growth or survival of reef organisms or may signal a change in the reef system.

Light is essential for zooxanthellae, the single-celled organisms which are found in most stony corals, octocorals and zoanthids, and some anemones and jellyfish. Suspended particles in the water absorb and scatter light, reducing light penetration. Light transmission can be measured directly with a transmissometer, or indirectly, by measuring suspended solids, water clarity with a Secchi disc, or the amount of light scattered by particles with a nephelometer. To measure the amount of light that is not scattered or absorbed by particles or soluble molecules, a transmissometer is used. This instrument is expensive, but it provides a field test that is not affected by the angle of the sun or time of day. The measurements taken in these different ways do not have any simple mathematical correlations, e.g., the Secchi disc depth cannot be used to predict the nephelometer reading, and suspended matter concentrations are not directly correlated with the percent of light transmission.

Parameter	Description	Instrument or Method
Temperature	Recent concern over widespread "bleaching" of reef organisms and its possible association with high water temperatures, along with more general concern over global warming have increased the interest in water temperature data from coral reef environments. Water temperatures range from 24.5 to 30.0^0 C.	Yellow Springs Instruments (YSI) multiparameter meter accuracy 0.4^o C resolution 0.1^o C
Dissolved oxygen	The amount of oxygen available for respiration by aquatic organisms, measured in parts per million (ppm)(equivalent to mg/L); low levels may indicate high bacterial concentrations.	YSI multiparameter meter accuracy 0.2 ppm resolution 0.01 ppm
Salinity	Salinity is an estimate of the concentration of dissolved salts in seawater, expressed as S o/oo or S ppt (parts per thousand). It is typically 34 to 37 ppt in reef waters.	YSI multiparameter meter accuracy 0.2 ppt resolution 0.1 ppt
Conductivity	Conductivity measures the ability of a solution to conduct electricity. This is dependent on the concentration of dissolved salts in the water. The units are mSiemens/cm. Conductivity in Caribbean waters is around 55 mS/cm.	YSI multiparameter meter accuracy (1% of reading +.001 mS/cm) resolution 0.01 mS/cm
pH	A measurement of the hydrogen ion concentration, ranging from 1 to 14, with "1" being the most acidic and "14" the most alkaline; a pH of "7" is considered "neutral". The pH of reef waters ranges from 7.5 to 8.4.	YSI multiparameter meter accuracy 0.2 units resolution 0.1 units
Light transmission	The amount of light available for photosynthesis of free-living and symbiotic algae (zooxanthellae) affects the growth of corals and	C-Star transmissometer sensitivity 1.25 mV

Parameter	Description	Instrument or Method
	other organisms.	
Visibility	An indirect measure of vertical light transmission.	Secchi disk resolution 0.25m
Turbidity	An indirect indication of light transmission, determined by passing a beam of light through a water sample (in the lab) and measuring the amount of light scattered by the particles at a 90° angle to the light beam. The amount of scattered light is directly proportional to the turbidity, as measured in Nephelometer Turbidity Units (NTUs).	Nephelometer resolution 0.01 NTU
Suspended solids	Sediments suspended in the water column affect light transmission and may reduce light available for photosynthesis and deplete dissolved oxygen.	Weight on Mettler analytical balance resolution: 0.0001 g
Photosynthetically active radiation (PAR)	PAR is the amount of sunlight available to plants for photosynthesis (wavelengths of 380 to 710 nm); it can vary depending on the sun's angle, cloud cover, suspended solids or light absorbing molecules in the water column.	Two Li-Cor quantum meters: one with an underwater sensor and cable for lowering the sensor over the side of the boat and one with a reference "deck" cell. Accuracy: 0.4% of reading resolution: 1μmol/sec-m^2
Nutrients	Nutrients are naturally found in coastal waters and required by organisms on the reef. Coral reefs typically occur in warm waters with very low nutrient concentrations. Increases can lead to changes in the relative abundance of organisms such as macroalgae or bacteria. The waters around St. John are subject to periodic nutrient increases from heavy rains which wash soil, animal feces, and organic debris from cleared areas down through the intermittent stream beds and into the ocean; from the Orinoco River, whose nutrient-laden water is carried by currents toward St. John during southerly winds in the Fall; and aerosols from the African Sahel, primarily in Summer.	Analysis of filtered sample for nutrients (analysis off-site)

Time and Personnel Requirements

The procedures involved in quarterly water quality monitoring and follow-up are done on three consecutive days, as listed below. The sites must all be sampled on the same day, with the laboratory preparation done the preceding day. The follow-up lab work must be done within 24 hours of sample collection.

- **Day 1: Field instrument preparation** (about 10 minutes for 1 person)
  Begin charging YSI battery; change dissolved oxygen membrane and solution on YSI sonde.

- **Day 3: Lab preparation** (about 4 hours for 1 person)
  Rinse all sample collection bottles three times with distilled water; in addition, acid rinse (using 2N HCl) the 250 ml sample bottles and nutrient bottles. Prepare solutions for calibrating YSI instrument; charge transmissometer battery; collect equipment needed; calibrate YSI multiparameter meter (early next morning).

- **Day 4: Data collection** (minimum of about 8 hours for 2 people in a boat powered by twin outboard engines). Measure the specified water quality parameters at all sites. Recalibrate YSI upon return from field.

- **Day 5: Laboratory procedures**
  Filtration of nutrient samples (about 4 hours for 1 person); filtration of total suspended solids (about 3 hours for 1 person); and nephelometer readings (about 2 hours for 1 person).

- **Day 6: Data entry**
  Data are entered, double checked and verified in the Excel spreadsheets. (2 hours for 1 person)

- **Days 8 & 9 (three and four days after day 5 lab procedures): Laboratory procedures**
  Weighing of filters with suspended solids to constant weight, calculating Total Suspended Solids for each sampling site and entering data in spreadsheet, calculating Extinction Coefficients and entering data in spreadsheets.

Temperature, salinity, dissolved oxygen, conductivity, pH, extinction coefficients (PAR) and light transmission are measured each quarter at 15 sites around St. John (for list of sites, see Appendix B). Secchi depth, cloud cover, wind speed, wind direction, and sea state are also recorded at each site. Four water samples are taken at each site to measure turbidity (NTUs), total suspended solids and nutrients. All sites are sampled in one day from a boat powered by twin outboard engines.

PREPARATION

Equipment and Supplies

During the afternoon on the day before field collection:

- *Organize equipment*
  - _ Field data sheets on clipboard
  - _ Map showing site locations
  - _ Secchi disc (with attached line marked in meter units)
  - _ Depth sounder or lead line
  - _ C-Star transmissometer, battery and voltmeter (and protective cushions)
  - _ Two Li-Cor spectroradiometers, microprocessing units and line marked in 1-m increments (with attached weight),
  - _ YSI multimeter and sonde in large cooler
  - _ 45 250 ml Nalgene sample bottles and 15 1 liter sample bottles, kept upright in cooler with ice, with extra bottles
  - _ Hand-held VHF radio
  - _ Tool kit
  - _ Ice chest with ice
  - _ Fins, mask and snorkel (optional)

- *Charge batteries*: Begin charging the YSI four days prior to collecting data and the transmissometer readout/battery a few days before field work. Be sure to connect into a line conditioner. (Failure to use a line conditioner may result in instrument failure due to current spikes, resulting in loss of time and considerable expense.) On the transmissometer, turn the knob to "BATTERY," the DC switch (on the right) to "CHARGE," and the AC switch to "ON". Let the battery charge to at least 13.1 volts.

- *Spectroradiometer photosensors*: Connect the underwater photosensor to the lowering frame using the three insulated screws and mylar “washer”. Connect carefully to the cable, taking care to orient the two connectors on the sensor with the proper receptacles in the cable connector. The reference cell is connected directly into the microprocessor.

- *Calibrate YSI multiparameter meter*: This task, which takes about 1 hour, should be done early morning of the field sampling day, following the procedure described in the following section. However, calibration solutions should be prepared the previous afternoon.

YSI Instrument Calibration

Equipment

_ YSI multiparameter meter and sonde
_ Calibration bottle
_ Clean, absorbent towel or cloth

Preparation

NOTE: For more details about using the YSI multiparameter meter, see the YSI Service Manual.

1. Change the membrane on the dissolved oxygen (DO) probe at least 24 hours before calibrating. If the probe is dry, it could release small air bubbles, throwing off the probe's readings. To prevent this, change out the membrane as described below, let sit 24 hours, then change the membrane and solution again, letting it equilibrate another 24 hours before calibration.
   - — Prepare the KCl electrolyte solution by filling the dropper bottle to the neck with distilled water and dissolving the KCl crystals in it.
   - — Remove the sonde from the bucket and shake off excess liquid. Remove the D.O. probe guard by turning it counter-clockwise. Remove the membrane.
   - — Rinse the probe with the electrolyte solution and shake off excess liquid.
   - — Holding the sonde in a vertical position, apply a few drops of the electrolyte solution to the tip of the probe. The fluid should completely fill the small moat around the electrodes and form a meniscus on the tip of the sensor. Make sure no air bubbles are stuck to the face of the sensor. If necessary, shake off the electrolyte and start over.
   - — Touching only the edges of a clean membrane, stretch it over the sensor.
   - — Roll the O-ring over the end of the probe, being careful not to touch the membrane surface. There should be no wrinkles or trapped air bubbles. Small wrinkles may be removed by tugging lightly on the edge of the membrane.
   - — Rinse off any excess electrolyte solution with distilled water.
   - — Change the KCl solution before returning sonde to the bucket (4 M KCl and pH 4 buffer in a 1:1 ratio).

2. Call the airport control tower for the current barometric pressure (**774-1836**). They will give you a 4-digit altimeter reading, e.g., 3001. Divide this number by 2992 to get atmospheres (atm). This will be used in the dissolved oxygen calibration.

   For example, 3001/2992 = 30.01 inches Hg/29.92 inches Hg per atmosphere = 1.003 atm).

3. Prepare the following standards:
   - ■ Conductivity calibration: 0.5M KCl solution (58.64 mS/cm) (18.64 gm KCl/500 ml solution).

- pH calibration: 7.0 buffer (500 ml) and 4.0 buffer (500 ml). (pH 10 is best for seawater, but pH 4 can be used).

4. Connect sonde to microprocessor. From Main Menu, select:
   - ☞ POWER
   - ☞ ESC
   - ☞ CALIBRATION

Conductivity Calibration

1. Remove calibration cup and stainless steel weight from the sonde.

2. Fill clean, rinsed calibration bottle with enough calibration standard to cover uppermost hole in the sonde housing (to black mark). Since conductivity readings are dependent on temperature, it is best to calibrate the sonde at the temperature of the seawater you will be sampling or at 25^{o} C. This can be accomplished using a water bath.

3. Slowly and carefully immerse the conductivity probe into the solution near, but not touching, the bottom. Gently rotate or tap the probe to remove any bubbles in the conductivity cell. Allow at least 1 minute for equilibration.

4. From Calibration Menu of the microprocessor:
   - ☞ Select CONDUCTIVITY.
   - ☞ Select COND to calibrate conductance.
   - ☞ Enter the calibration value of the standard: 58.64 mS/cm.
   - ☞ After the readings are stable, press "Y" to complete calibration.

5. Rinse the sonde in cool tap water. Gently shake excess water from the sonde and dry carefully with soft, clean cloth. Do not touch the membrane of the DO probe.

pH Calibration (2 point)

1. Fill a clean calibration cup to the black mark with pH 7 buffer. Slowly and carefully immerse the probe end of the sonde into the solution. Allow 1 minute for temperature equilibration.

2. From Calibration Menu of the microprocessor:
   - ☞ Select pH.
   - ☞ Select pH 2 POINT.
   - ☞ Enter the pH value of the buffer: 7.0
   - ☞ Press ENTER.
   - ☞ After the readings are stable, press "Y" to complete calibration.

3. Rinse the sonde in cool tap water and gently dry sonde guard and probes. Do not touch the membrane of the DO probe.

4. Fill a clean calibration cup to the black mark with the second pH solution (4 pH). Repeat steps 1-3 above, entering the appropriate pH value of the buffer.

Dissolved Oxygen % Calibration

1. Place 1 cm of tap water inside a clean, empty calibration cup with the probe guard installed.

2. Place the probe end of the guard into the calibration cup, but not in the water. Make certain that the water does not cover the DO membrane, no water droplets are on the membrane and that the temperature at which the calibration is done is as close as possible to the temperature of the seawater you will be sampling. Touch the edge of a KimWipe or sponge to an edge of the membrane to draw off any water droplets. Wait 10 to 15 minutes for the air above the water to saturate.

3. From Calibration Menu of the microprocessor:
   - ☞ Select CALIBRATE.
   - ☞ Select DO%.
   - ☞ Enter the current barometric pressure in mm Hg (see "Preparation" above): atm X 760mm/atm (e.g., 3001/2992atm x 760mm Hg/atm = 762mm).
   - ☞ After the readings are stable, press "Y".

NOTE: Before taking readings in the field, make sure the sensors are "enabled" or "on". To do this, from Calibration Menu of the microprocessor, select SENSOR. An asterisk (*) indicates whether the sensor is turned on. To add or remove an asterisk, type the number of the sensor.

Instrument Maintenance

1. Periodically clean the conductivity probe with a brush.

2. Periodically wipe the pH probe with tap water and use lens cleaning tissue to remove all foreign material from the glass probe.

3. Keep the DO probe moist when not in use by placing a damp sponge in the calibration cup.

4. Store the rinsed probe in a solution of 50% pH 4 buffer and 50% 4M KCl.

DATA COLLECTION

Before leaving the dock, fuel the boat.

The same water quality parameters are measured at each site. It does not matter in which order the parameters are measured, but following the same sequence at each site helps to prevent omissions.

At Each Field Site

Time, Weather, and Depth

Record time, cloud cover (%), sea state (in feet), wind (in knots), and depth (in feet, using an electronic depth sounder).

Nutrient Sampling

1. Find the three 250 ml Nalgene sampling bottles and one 1 l bottle whose numbers correspond to the site location. (Use the same bottles for the same site each month.)

2. Be exceptionally careful not to touch the lip or inside of the bottle or cap with anything but seawater. Rinse each bottle and cap three times with seawater at the site, then fill the bottle from below the surface, amidships on the windward side of the boat.

3. Place the 250 ml bottles upright in the cooler with ice. The 1 liter bottles do not have to be iced.

NOTE: No smoking or drinking colas is permitted while on the boat taking samples or during lab work, as either may affect nutrient levels in the sample.

Water Visibility

If ocean floor is visible, record "B" for bottom. If it is not visible:

1. Lower the Secchi disc into the water until the black/white pattern is no longer visible. Note depth (as indicated on the line in meters).

2. Slowly pull the disc up and note depth as soon as the disc becomes visible again.

3. Average the two depths and record in meters.

YSI Multimeter

1. Carefully remove the YSI sonde multimeter from the cooler and lower it into the water to a depth of 1m (as marked on the data cable).

2. Allow the instrument to thermally stabilize, then press "POWER". Record temperature (°C), salinity (ppt), pH, conductivity (mS/cm), and dissolved oxygen (ppm). Take 2 additional sets of data at each site, for a total of three replicate readings per site. Also record the depth in feet.

3. Turn off the instrument, insert the sonde into the storage bottle with a little seawater in it (to keep the sonde probes moist) and return it to the cooler.

Light Transmission

1. Holding the transmissometer sensor by the harness and **not the electrical cable**, slowly lower it into the water to a depth of 1 meter.

2. Turn voltmeter to "DC volts". Record three readings in millivolts (mV).

3. Turn voltmeter to "Off" and carefully bring the sensor aboard and place on cushioning material.

4. Periodically check that the cable connection to the instrument is tight.

Spectroradiometer

(Extinction Coefficients)

1. Lower the quantum sensor on the frame by the attached nylon line (not the cable), until the quantum sensor is at 1 m depth. Hold the frame away from the boat, making certain the underwater sensor is not being shaded by the boat or your shadow.

2. Place the reference cell on the deck of the boat. Make certain the cell is always in direct sunlight and not shaded.

3. Turn on both microprocessors. Simultaneously press "HOLD" on both microprocessors to obtain readings from the reference cell and the underwater sensor at 1 m depth and record. Take three readings from both the underwater and reference cells for each depth. Lower the frame to 5 m or as deep as it can be lowered without hitting the bottom in shallow water (eg. 1.5 m may be all that is possible). Simultaneously press "HOLD" on both microprocessors to obtain readings at the surface and the second depth and record.

4. Turn off the microprocessors and carefully bring the underwater sensor and frame aboard and secure from breakage.

After Returning to the Lab

The last step listed below, entering the collected data into the computer, may be done the next day, but should be done as soon as possible to minimize errors. The other steps listed below must all be done the same day as the field work.

Clean-Up

1. Remove YSI and Li-Cor microprocessors and transmissometer display. Remove batteries from microprocessing units of spectroradiometers.

2. Rinse all gear in fresh water. Keep cable connectors dry.

   — Carefully disconnect Li-Cor underwater photosensor and put in a foam cup. Keep screws and mylar washer in plastic bag.

3. Using WD-40, wipe inside and outside of threads on cable connectors, and outside metal parts, but not the electrical connections (pins).

4. With a slightly damp towel, wipe outsides electrical units to remove salt and water. Dry well.

5. Place water samples upright in the refrigerator or leave upright on ice in the cooler.

6. Recoil electrical cords neatly but not tightly.

YSI Multimeter

1. Recalibrate YSI multimeter for pH and conductivity. Record calibrations on original data sheets (e.g., "reads 61.00 mS/cm for 58.64 ms/cm std, temperature = 25.8^{o} C").

2. Wipe YSI microprocessor and place in storage box. Store sonde in bucket with several inches of a solution of 4 M KCL and pH 4 buffer (1:1).

3. Battery does NOT have to be run down, runs down within 4-5 days of non-use.

Transmissometer

1. Four days before next use, plug in battery to battery charger, turn AC switch on, and turn battery switch to "CHARGE". Check about eight hours later. Battery is recharged when reading is about 13.0 v DC.

LABORATORY PROCEDURES

Filtration of Nutrient Samples

Equipment and Supplies

_ Vacuum pump with surge protector
_ Acid rinsed 1 liter vacuum flask
_ Acid rinsed glass filter holder and funnel
_ Clamp
_ Forceps
_ 1-liter graduated cylinder
_ 0.45μm glass fiber, 42 mm diameter filter papers
_ Distilled water (DI)
_ 250 ml Nalgene bottles with water samples
_ Clean, acid-rinsed, distilled water-filled 60 ml sample bottles

Procedure

1. Keep field sample bottles (250 ml, 3 per site) in cooler, on ice prior to filtration.

2. DO NOT TOUCH INSIDE OF CAPS OR BOTTLES WITH ANYTHING EXCEPT SAMPLE!

2. Plug vacuum pump with trap into line conditioner. Connect vacuum tubing between vacuum pump and vacuum flask.

3. Using forceps, place 0.45μm filter paper on filter holder and clamp the assembly together.

4. Invert sample bottle several times to mix. Pour approximately 100 ml of the sample into the filtering assembly and turn on the pump. (Turn pump off each time it finishes filtering so as to prevent damage to the pump.)

5. Use the initial filtrate to rinse the vacuum flask and the clean empty 60 mlsample bottle, then discard filtrate.

6. Filter approximately 100 ml of the seawater sample. Pour 50 ml of the filtrate (just below the shoulder of the sample bottle) into the clean, empty 60 ml sample bottle that was just rinsed with filtrate.

7. Write the sample site number, sampling date, and "St. John" on each bottle. Store upright on ice.

8. Place the sample remaining in the 250 ml Nalgene field sample bottle aside to equilibrate to room temperature for nephelometer analysis.

9. Rinse the vacuum flask and filter apparatus three times with distilled water. Let them drain well. Repeat steps 3 through 9 with each of the remaining 44 samples.

10. Rinse three clean, empty 60 ml sample bottles with distilled water (three

rinses each), fill with DI water, mark the bottles "DI blank" and store on ice.

10. Place all 48 of the 60 ml bottles with filtered samples in the freezer. Keep all sample bottles in an upright position and frozen.

Clean-up

12. Wash all glassware and filter holder in Alconox detergent, rinse three times with DI, and then once with 2N HCl.
    - To prepare the 2N HCl solution: use a 1 l graduated cylinder to measure 800 ml DI water and transfer into a large flask. Wearing safety glasses and in a well-ventilated room, use a graduated cylinder to carefully measure 200 ml concentrated HCl acid. Take care not to inhale the HCl fumes. Slowly add the 200 ml of conc. HCl in the graduated cylinder to the 800 ml DI water in the flask. Swirl the approximately 2N HCl solution gently to mix. Pour into a dark, bottle identified as 2N HCl.
    CAUTION: ALWAYS ADD ACID TO WATER or risk an explosion.

13. After the final wash and rinse, oven dry the glassware overnight, cover with parafilm and store.

14. Rinse all sample bottles three times with tap water, followed by three rinses with DI water. Secure caps tightly on the bottles.

Shipping

Keep the filtered nutrient samples in the freezer until they are shipped via Express Mail, in a styrofoam box with blue ice. (Only on Monday or Tuesday). First call Betty Buckley to make sure she will be there to analyze the samples when they arrive.
Send to:

Betty Buckley
Graduate School of Oceanography
URI
Narragansett, RI 02882-1197
(401) 874-6619

Data Entry

Betty Buckley sends both paper and electronic copies of the data. They are archived at the Biosphere Reserve Center and sent annually with all other water quality data to the Water Resources Division of the NPS, for incorporation in the STORET database for national parks.
Send to:

Dr. Dean Tucker
NPS, WRD
1201 Oakridge Dr.
Ft. Collins, CO 80525
dean_tucker@nps.gov

Suspended Solids

Equipment

_ Mettler analytical balance
_ Vacuum pump with water trap and surge protector
_ Vacuum filter flask
_ Filter base
_ Filter cylinder
_ Clamp
_ Forceps
_ 1-liter graduated cylinder
_ Beaker
_ Drying oven
_ Desiccator
_ Rinsed and oven-dried to constant weight 0.45 μ cellulose acetate filters
_ Distilled water (DI)
_ 2 N HCl solution
_ Water samples in 1 liter bottles
_ Clean and dry petri dish for each sample (15)

Procedure

1. Prior to field sampling: use a ballpoint pen to label each filter with the sampling date and site (e.g., #15 Mar 2000); filter 50 -100 ml distilled water through each of 15-20 0.45μm cellulose acetate filter papers; place filters in a glass container in the drying oven on low heat and dry to constant weight. Place in desiccator.

2. Using forceps, remove the labeled, rinsed and oven-dried 0.45 μm cellulose acetate filter from desiccator. Place filter on previously tared analytical balance and record weight.

3. Assemble vacuum filter flask, filtering apparatus, trap, and vacuum pump. Plug into line conditioner.

4. Rinse the filter base and filter cylinder glassware three times with DI.

5. Using forceps, transfer weighed filter onto filter base. Put filter cylinder on top of filter and base and clamp together.

6. After shaking water sample 10 times, pour into the graduated cylinder, filling it to the 1-liter mark.

7. Pour sample from graduated cylinder into filter cylinder (not full).

8. Turn on vacuum pump. Add more sample as filtering proceeds until entire 1000 ml of sample has been poured into the filter cylinder.

9. After the sample has been filtered, add about 50 ml of DI, filtering to remove salts from the filter paper.

Procedure

10. Turn off the pump. Pour filtrate out of flask, making sure that the filtrate does not flow into the hose. Remove clamp and filter cylinder.

11. Using a clean forceps, carefully grasp an edge of the filter paper without residue, remove it from the base, and place it in a clean petri dish, residue side up.

12. After oven-drying at low heat (60^{o} C) for two days, place four or five of the petri dishes with filters in the desiccator and allow to come to room temperature.

13. Weigh the filter papers with residue on a tared analytical balance. Record the weight, sample number, and date. For a sample data sheet, see Appendix E. Return filter to petri dish and oven dry overnight. Remove petri dish and filter from oven and place in desiccator until room temperature. Reweigh the filter on the tared analytical balance. Continue to oven dry the filter in the open petri dish until a constant weight is achieved.

14. Record the constant weight, sample number, volume filtered and date sample was taken. This weight minus the initial filter weight equals the amount of total suspended solids (TSS) (mg per liter) in the sample.

15. To determine the amount of non-carbonate suspended solids:

    A. Using forceps, transfer dried, weighed filter with TSS (#13 above) on to filter base. Put filter cylinder on top of filter and base and clamp together.

    B. Pour approximately 20 ml of a 2 N HCl solution into filter cylinder.

    C. Let stand 5 minutes, so the acid can dissolve the calcium carbonate on the filter.

    D. Turn on vacuum pump.

    E. After the acid has been filtered, add about 50 ml of DI, filtering to remove acid from the filter paper.

    F. Turn off the pump. Remove clamp and filter cylinder.

    G. Using a clean forceps, carefully grasp an edge of the filter paper without residue, remove it from the base, and place it in its petri dish, residue side up.

    H. After oven-drying at low heat (60^{o} C) for two days, place four or five of the petri dishes with filters in the desiccator and allow to come to room temperature.

I. Weigh the dried, acid-washed filter paper with residue on a tared analytical balance. Record the weight for that sample number. Return filter to petri dish and oven dry overnight. Remove petri dish and filter from oven and place in desiccator until room temperature. Reweigh the filter on the tared analytical balance. Continue to oven dry the filter in the open petri dish until a constant weight is achieved.

Data Entry

16. Record the constant weight after acid rinse in the "acid washed filter + residue" column. Subtract the initial weight of the filter from the "acid washed filter + residue" weight to determine the amount of non-carbonate suspended solids in the sample (mg per liter).

Clean-up

17. Rinse all glassware 3 times with tap water and 3 times with DI, inside and out. Place on drying rack. Wipe pump with slightly damp cloth. Clean out water trap.

Archival

18. Save the acid-washed filters in their original, marked (sample# and date) petri dishes for one year.

Nephelometer Readings

Equipment and Supplies

_ Turner Model 40 nephelometer with line conditioner
_ 2.0 and 20 NTU standards
_ Distilled water (DI)
_ Acetone
_ KimWipe
_ Bottles of water samples (room temperature)
_ Clean unscratched cuvettes

Procedure

1. Plug the nephelometer into the line conditioner**.** [**The light shield (black cap) should remain on the cylinder except when samples are being put in or removed**.] Turn on the instrument and allow it to warm up for at least 1 hour before using.

2. Calibrate the nephelometer using the 2.0 NTU and 20 NTU standards. (Follow the manufacturer's directions) **The 2.0 NTU standard should be refrigerated, stored away from light, and replaced every year. The 20 NTU standard is good for two years.**

3. Remove the light shield and place a clean cuvette in the cylinder. Handle the bottle by the top and bottom to prevent fingerprints on the sides of the cuvette. They etch the glass and affect the readings.

4. While watching the display, rotate the cuvette until it's at the position that gives the lowest reading. Mark the cuvette and cap at the 3 o'clock position. To minimize interference from imperfections in the glass, the cuvette should be in this same relative position each time you take a reading.

5. Rinse the empty cuvette with DI, and then with some sample.

6. **Gently shake the 250 ml sample bottle to resuspend suspended solids. Do not shake too vigorously or bubbles will be created, which will introduce errors in the readings**. Fill the empty cuvette with sample and recap. If sample spills down the outside of the bottle, rinse it with DI and then acetone, then use a KimWipe to remove all residue. Keeping the outside of the sample bottle dry and free of fingerprints will save you time.

7. Place the cuvette in the cylinder, lining up the mark on the bottle with the 3 o'clock position on the nephelometer. Replace the light shield. (The light shield should remain in place except when placing or removing cuvette.)

8. On a data sheet, record the site number and sample reading #1. The display will fluctuate; take the most stable reading. Do not wait so long that suspended matter begins to settle.

9. Rinse the cuvette 3 times with DI and with a small amount of the next sample. Repeat steps 3 through 9 for each sample (n=45).

10. Midway through your testing, repeat the process of reading the 2.0 NTU calibration standard to check for drift. Record the reading (eg. 2.0 NTU standard reading 1.9) but do not recalibrate the nephelometer.

Clean-up

11. When finished, rinse empty 250 ml sample bottles three times with DI and once with 2N HCl. Fill with DI, cap and store.

Data Entry

12. Enter the nephelometer readings in the computer.

Data Analysis

You must be careful in interpreting nephelometer readings, because they can fluctuate widely due to the small volume of each sample, the drift in the instrument and other factors not directly pertaining to water clarity. Look for consistent trends in the data, or substantial increases or decreases over time. For example, if after several months of values of less than 1.0 NTU at a particular site you have a series of values over 2.0 NTU, you can generally conclude that turbidity has increased significantly. Smaller changes are harder to interpret.

DATA ENTRY AND MANAGEMENT

Water quality data gathered in the field should be entered on the computer within a week of collection. The data are entered in an Excel spreadsheet file and archived on ZIP diskette, hard drive and in Ft. Collins in a STORET database. Data are double checked and verified. Data outside the average range of values are tested and evaluated for inclusion in the dataset by the data manager. The entry "-9.00" is placed in cells for missing data. Nutrient concentrations, total suspended solids and extinction coefficients were added to the database in early 1998. Statistical summaries are produced by Water Resources Division and sent to Virgin Islands National Park.

Extinction coefficient

Data collected using the LiCor spectroradiometers are entered in the Extinction coefficient spreadsheet (Excel). Formulae embedded in cells automatically calculate the extinction coefficient for each site. The formula is:

$$\mathbf{k = [- \ln (I_Z / I_O)] / z}$$

k= extinction coefficient (0-1); I_Z= intensity of light (μmoles/sec-m^2) measured at depth Z ; I_O= intensity of light measured at surface or depth 0; Z = depth (meters) light intensity is being measured.

The Excel spreadsheet for extinction coefficients is shown in Appendix F.

Percent light transmission

Data collected using the C-Star transmissometer are entered in the transmissometer spreadsheet (Excel). Formulae embedded in cells automatically calculate the percent light transmission from the millivolts recorded from each site. The formula is:

$$\mathbf{Tr = [(V_{sig} - V_{dark})/(V_{ref} - V_{dark})] \times 100}$$

Tr= percent light transmission (0-100%); $\mathbf{V_{sig}}$ = millivolts of current from voltmeter reading in field ; $\mathbf{V_{dark}}$ = millivolt reading when the light beam is blocked (0 transmission), determined at the factory and provided in the factory calibration documentation; $\mathbf{V_{ref}}$ = millivolts determined at the factory and provided in the calibration documentation.

The Excel spreadsheet for percent light transmission is shown in Appendix G.

APPENDIX A

STORET spreadsheet data fields

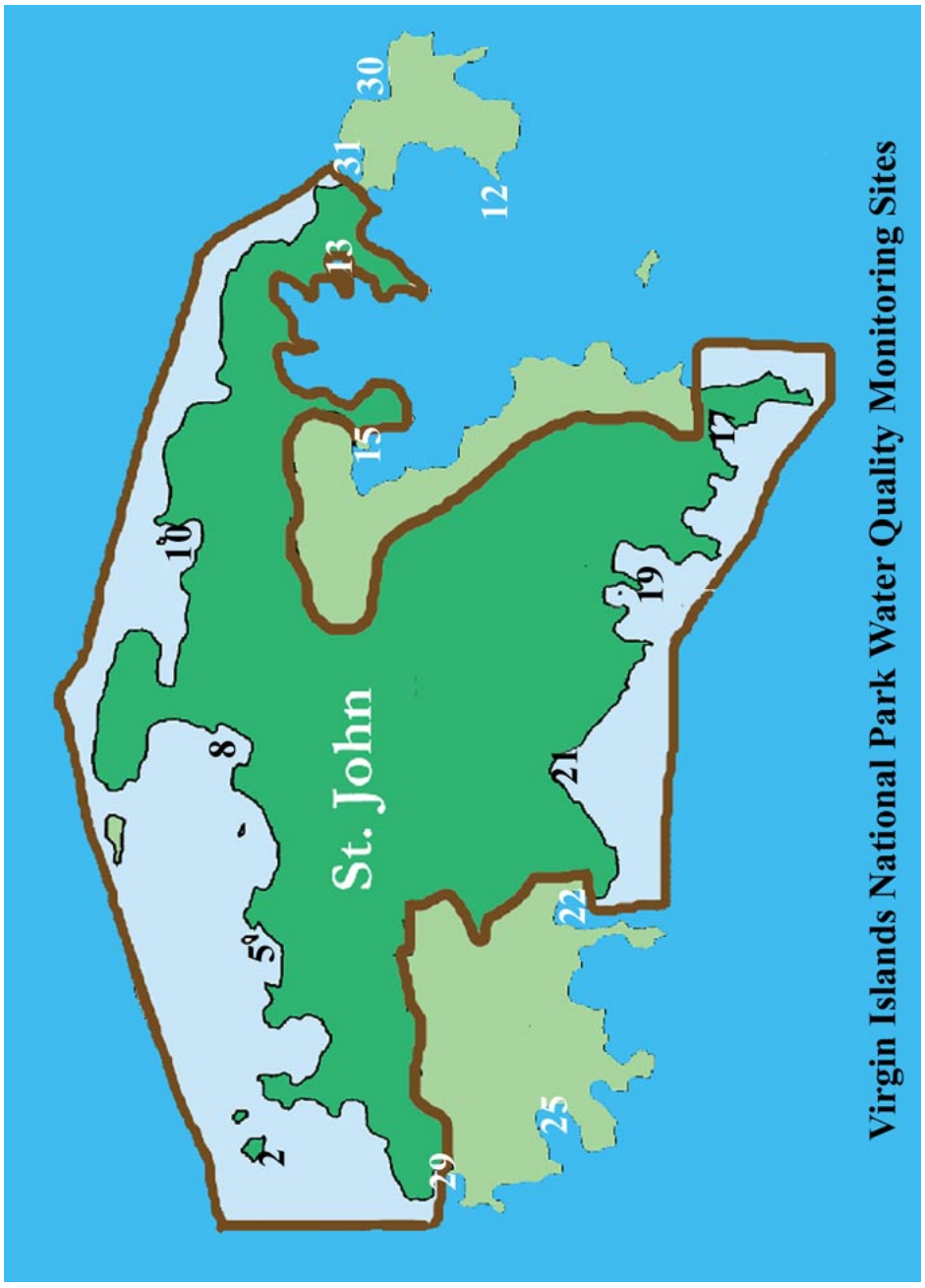
Column Name	Description
SITE	Site number
TEMP	Temperature, water in ^{o}C.
DISSOXY	Oxygen, dissolved (mg/l).
SALIN	Salinity, parts per thousand (ppt).
SECCHI	Transparency, Secchi disc in meters. This is the actual field data, entering "B" where bottom could be seen, otherwise converting feet to meters.
SECCHIST	Transparency, Secchi disc in meters. This is a numeric column. If the bottom was not seen, enter the meters recorded in the "SECCHI" column. If the bottom was seen ("B"), enter the depth of the water in meters (DEPTH column) in this column.
TRANS	Light transmission, percent.
WIND	Wind velocity, mph and direction. This is a data field which uses: a character field ("CALM"); or number field (e.g. 5, <5 or 5-10)
WINDST	Wind velocity, mph and direction. This is a numeric field which uses: 0 if "calm"; the actual number; 1/2 the number if "<"; or the mean of a range (e.g. 5-10 = 7.5).
DATE	The date the sample was taken.
PH	pH, field (standard units).
COND	Specific conductance, field (mS/cm).
DEPTH	Depth in meters to bottom at sampling site. Convert field data (in feet) into meters by dividing by 3.3.
TURB	Turbidity, laboratory (NTU).
SECCPER	Secchi depth/water depth (percent) SECCPER=SECCHIST/DEPTH x 100 (E.g., If SECCHI is "B", DEPTH = 4.0, then SECCPER= 4.0/4.0 x 100 = 100. IF SECCHI is 3.0 and DEPTH is 4.0, SECCCPER=3.0/4.0 x 100 = 75)
SEA	Sea state (feet). This is a data field which uses a character field ("CALM") or number field (e.g. 5, <5 or 5-10)
SEAST	Sea state (feet). This is a numeric field which uses: 0 if "calm"; the actual number; 1/2 the number if "<"; or the mean of a range (e.g. 5-10 = 7.5).
CLOUD	Cloud cover (percent). This is a data field that uses a character field ("rain") or number field (e.g. 5, <5 or 5-10).
CLOUDST	Cloud cover (percent). This is a numeric field which uses: 0 if "rain"; the actual number; 1/2 the number if "<"; or the mean of a range (e.g., if CLOUD is a single number (20) then enter that number (20) in CLOUDST; if CLOUD is less than a number (<10), then CLOUDST is one half the number (10/2=5); if CLOUD is a range (5-10), then CLOUDST is the average of the range (7.5)).
COMMENTS	The time at which the sample was collected in 2400 clock (e.g. 1 pm is 1300).

APPENDIX B

WATER SAMPLING SITES

The sites are listed below in the order in which they are sampled, moving clockwise around the island. "VINP" means Virgin Islands National Park; "VICRNM" means Virgin Islands Coral Reef National Monument; and "VI Terr" means Virgin Islands Territorial government waters.

SITE	JURISDICTION	LOCATION	WATERSHED
29	VINP	**NPS Dock**	developed
2	VINP	**Henley Cay**	undeveloped
5	VINP	**Trunk Bay**	undeveloped
8	VINP	**Maho Bay**	partially developed
10	VINP	**Leinster Bay**	undeveloped
31	VI Terr	**East Haulover Bay**	partially developed
30	VI Terr	**Newfound Bay**	undeveloped
12	VI Terr	**Long Point**	undeveloped
13	VICRNM	**Water Creek**	undeveloped
15	VI Terr	**Coral Bay Dock**	developed
17	VINP	**Salt Pond Bay**	partially developed
19	VINP	**Yawzi Point**	undeveloped
21	VINP	**Reef Bay**	undeveloped
22	VI Terr	**Fish Bay**	developed
25	VI Terr	**Great Cruz Bay Dock**	developed


Virgin Islands National Park Water Quality Monitoring Sites
St. John
2
5
8
10
12
13
15
17
19
21
22
25
29
30
31

APPENDIX C **FIELD DATA SHEET**

Collectors_____

Date_____

Site	Time	Temp °C	DO mg/l	Sal ppt	Secchi m	Trans % 1-97%	Wind mph	pH	Cond mS/cm	Depth m	Neph NTU	Sea ft	Cloud %
Henley 2													
2													
2													
Trunk 5													
5													
5													
Maho 8													
8													
8													
Leinster 10													
10													
10													
Haulover 31													
31													
31													

Site	Time	Temp °C	DO	Sal	Secchi	Trans %	Wind	pH	Cond	Depth	Neph	Sea	Cloud
Newfound 30													
30													
30													
Long Pt 12													
12													
12													
Water Crk 13													
13													
13													
Coral Doc 15													
15													
15													
Salt Pond 17													
17													
17													

ST. JOHN WATER QUALITY

Site	Time	Temp °C	DO	Sal	Secchi	Trans %	Wind	pH	Cond	Depth	Neph	Sea	Cloud
Yawsi 19													
19													
19													
Reef Bay 21													
21													
21													
Fish Bay 22													
22													
22													
Great Cru 25													
25													
25													
NPS Dock 29													
29													
29													

APPENDIX D

NEPHELOMETER READINGS DATASHEET

SITE	Sample "A" reading (NTU)	Sample "A" reading (NTU)	Sample "A" reading (NTU)
2	.29	.31	.30
5	.22	.21	.39
8	.41	.41	.52
10	.15	.19	.14
12	.11	.10	.15
13	.38	.44	.39
15	2.9	2.9	3.1
17	.26	.21	.22
19	.33	.33	.31
21	.29	.27	.26
22	.46	.38	.39
25	.68	1.3	.98
29	2.2	2.3	2.1
30	.23	.22	.27
31	.12	.17	.16

APPENDIX E

SUSPENDED SOLIDS

SITE	weight of filter (gm)	initial dry weight of filter + solids (gm)	final dry weight of filter + solids (gm)	weight of total suspended solids (>0.45µm) (gm)	volume (l)	total suspended Solids (mg/l)	weight of acid-washed filter + solids (gm)	non-carbonate suspended solids (mg/l)
2	0.0927	.0957	.0957	.0030	1.00	3.0	.0947	2.0
5	.0928	.0949	.0949	.0021	1.00	2.1	.0948	0.1
8	.0934	.0968	.0964	.0030	1.00	3.0	.0961	0.3
10	.0929	.0954	.0954	.0025	1.00	2.5	.0944	1.0
12	.0915	.0942	.0942	.0027	1.00	2.7	.0942	0.0
13	.0930	.0969	.0962	.0032	1.00	3.2	.0944	1.8
15	.0920	.1418	.1398	.0478	1.22	39.2	.1300	9.8
17	.0912	.0958	.0958	.0046	1.00	4.6	.0954	0.4
19	.0937	.0965	.0955	.0018	1.00	1.8	.0944	1.1
21	.0928	.1005	.1005	.0077	1.00	7.7	.1005	0.0
22	.0930	.1095	.1075	.0146	1.00	14.6	.1056	1.9
25	.0924	.0994	.0994	.0070	1.00	7.0	.0990	0.4
29	.0910	.1266	.1226	.0316	1.00	31.6	.1222	0.4
30	.0923	.0951	.0951	.0028	1.00	2.8	.0919	3.2
31	.0928	.1046	.1046	.0118	1.00	11.8	.1043	0.3

APPENDIX F

Datasheet for calculating Extinction coefficients (k) using photosynthetically active radiation (PAR) readings from a spherical quantum detector (μmoles/ sec-m^2). Data in shaded columns are entered in the spreadsheet from field sheets. Information in unshaded columns is calculated by formulae embedded in the spreadsheet. The calculated extinction coefficient (k) at each site is found in the column to the right. A negative k value indicates a problem: the underwater sensor may have been shaded from the sunlight by the boat or cable; or there may have been an error in recording field data or in data entry.

DATE	Site	Time	Deck Cell	Water sensor	Depth	I	Mean I	k
			I	I	m	μmoles/ sec-m^2	μmoles/ sec-m^2	
17-Mar-98	2	1030	1650	785.7	1.0	785.7	760.7	
17-Mar-98	2		1700	883.6	1.0	857.6		
17-Mar-98	2		1818.7	704.2	1.0	638.9		
17-Mar-98	2	1030	1646.1	750	2.0	751.8	751.3	0.01
17-Mar-98	2		1692.8	789.2	2.0	769.2		
17-Mar-98	2		1726.7	767	2.0	732.9		
17-Mar-98	5	1035	316.5	144.6	1.0	144.6	166.4	
17-Mar-98	5		404.3	181.8	1.0	142.3		
17-Mar-98	5		892.1	598	1.0	212.2		
17-Mar-98	5		440.8	163.9	3.0	117.7	129.0	0.13
17-Mar-98	5		327.3	138.9	3.0	134.3		
17-Mar-98	5		311.5	132.8	3.0	134.9		
17-Mar-98	8	1055	2389	1281.8	1.0	1281.8	1257.7	
17-Mar-98	8		1919	974.7	1.0	1213.4		
17-Mar-98	8		2229	1192.3	1.0	1277.9		
17-Mar-98	8		2135	961.8	2.3	1076.2	1170.1	0.06
17-Mar-98	8		2160	1099.7	2.3	1216.3		
17-Mar-98	8		2203	1123	2.3	1217.8		

APPENDIX G

Datasheet for calculating percent transmission of light using millivolt readings from the transmissometer (volts). Data in shaded columns are entered in the spreadsheet from field sheets. Information in unshaded column is calculated by formulae embedded in the spreadsheet.

Transmissometer worksheet			
		reading from field	calculated
DATE	SITE	volts	% transmission
28-Dec-98	2	4.46	89.9
28-Dec-98	2	4.43	89.3
28-Dec-98	2	4.41	88.9
28-Dec-98	5	4.49	90.5
28-Dec-98	5	4.49	90.5
28-Dec-98	5	4.50	90.7
28-Dec-98	8	4.18	84.2
28-Dec-98	8	4.19	84.4
28-Dec-98	8	4.18	84.2
28-Dec-98	10	4.45	89.7
28-Dec-98	10	4.44	89.5
28-Dec-98	10	4.45	89.7
28-Dec-98	12	4.45	89.7
28-Dec-98	12	4.45	89.7
28-Dec-98	12	4.45	89.7
28-Dec-98	13	4.12	82.9
28-Dec-98	13	4.16	83.7
28-Dec-98	13	4.16	83.7